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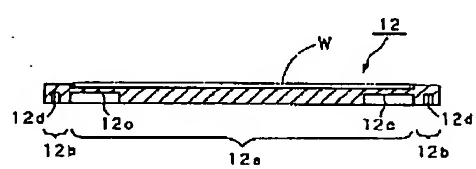
(54) **SUSCEPTOR FOR CRYSTAL GROWTH AND CRYSTAL GROWTH DEVICE, AND EPITAXIAL WAFER AND ITS PRODUCTION**

(57) Abstract:

PROBLEM TO BE SOLVED: To provide the subject device intended for the epitaxial growth of a single crystal on the surface of a substrate by making a reactant gas flow on the surface of the substrate at elevated temperatures while making the heat content per unit area of the peripheral rim of the substrate mount area of a susceptor lower than that at the central part of the mount area so as to improve both the film thickness uniformity and impurity concentration uniformity in the single crystal plane.

SOLUTION: This device works as follows: a silicon substrate W is placed on a recess provided on the mount area 12a of a disc-shaped susceptor 12 made of carbon or the like and turned via a rotating shaft member inserted into an engagement hole 12d provided on the reverse side of the peripheral area 12b; a reactant gas comprising silane gas and dopant gas is then made to flow on the surface of the substrate W while heating the substrate W to e.g. about 1,130°C by the aid of halogen lamps or the like disposed therearound to accomplish epitaxial growth of a silicon single crystal on the substrate W; in producing the epitaxial wafer, an annular groove 12c is provided on the peripheral rim of the mount area 12a of the susceptor 12, or a projection is provided at the central part to make the heat content of the peripheral rim lower than that at the central part, thereby making the temperature of the peripheral rim of the substrate W lower.



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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] In case this invention grows epitaxially on substrates, such as a silicon wafer, it relates to the crystal-growth equipment using the susceptor for crystal growths and this which support a substrate and an epitaxial wafer, and its manufacture method.
[0002]
[Description of the Prior Art] In recent years, the epitaxial wafer to which the vapor growth of the single-crystal-silicon thin film (epitaxial layer) was carried out by predetermined high impurity concentration is used on the silicon substrate of very low resistivity as a silicon wafer for MOS devices. This epitaxial wafer can be equipped with the property which was [improvement / parasitic-capacitance reduction, prevention of a soft error, / in gettering capacity] excellent while it can suppress the influence of crystal defects, such as COP (Crystal Originated Particle) produced to a raising crystal wafer, and its yield of the gate oxide film of an MOS device improves.
[0003] In manufacture of this epitaxial silicon, with diameter[of a large quantity]-izing of a silicon wafer, the epitaxial crystal-growth equipment of not the conventional batch type but single wafer processing mainly comes to be used, and the thing for diameters of a large quantity, such as 300 etc.mm, is developed. With this single-wafer-processing equipment, while laying a silicon substrate on one susceptor allotted to the level state in the chamber, a susceptor is made to mainly heat by sources of heating, such as an infrared lamp arranged in the circumference, and the silicon substrate laid with the heat from this susceptor is changed into the elevated-temperature state.
[0004] And the vapor growth is performed by passing reactant gas on the silicon substrate of an elevated-temperature state, rotating a susceptor. In addition, as shown in drawing 7 , the above-mentioned conventional susceptor 1 inserts the supporter 2 made from a quartz in fitting hole 1a which formed in circular plate-like the carbon with which the front face was coated with the silicon carbide, and was formed in the undersurface, and is supported possible [rotation] in the chamber.
[0005]
[Problem(s) to be Solved by the Invention] However, the following technical problems are left behind with the above-mentioned conventional epitaxial crystal-growth means. That is, also in the epitaxial wafer, since improvement in the higher yield and reliability is called for, still more uniform thickness and resistance are especially demanded over the whole wafer surface. If the distribution of resistance is investigated while there is a phenomenon in which the periphery section becomes thick compared with a center section as shown in (a) of drawing 8 when the thickness distribution of the epitaxial layer grown up with the conventional means is investigated, as shown in (b) of drawing 8, there is a phenomenon in which the periphery section becomes low and it is necessary to correct such heterogeneity from a center section. As one of the factors to which the thickness of the periphery section becomes thick, the so-called auto dope phenomenon can be considered as one of the factors to which it is thought that it is based on disorder of the flow of the reactant gas in the periphery section, and the resistance of the periphery section falls. This auto dope phenomenon is a phenomenon in which the boron which evaporated from the edge portion of a substrate will be incorporated by the epitaxial layer of the surface periphery section, high impurity concentration becomes high, and resistance falls, when boron grows an epitaxial layer on the low resistance silicon

substrate added by high concentration. In addition, the thickness and the resistance of an epitaxial layer were difficult to raise the homogeneity of the local periphery section especially only at these, although the proposal of the method of enlarging a center section for the power of a lamp relatively to the periphery section, the method of supplying boron to a wafer center section from the chamber upper part, lowering the resistance of a center section, and attaining equalization, etc. was made in order to receive influence in temperature, the flow of gas, etc.
[0006] this invention was made in view of the above-mentioned technical problem, and aims at offering the crystal-growth equipment using the susceptor for crystal growths and this which can raise the thickness homogeneity and high-impurity-concentration homogeneity within a field in epitaxial growth and an epitaxial wafer, and its manufacture method.
[0007]
[Means for Solving the Problem] The following composition was used for this invention in order to solve the aforementioned technical problem. Namely, in case reactant gas is passed on the substrate of an elevated-temperature state and a crystal is grown up into a substrate front face, it is the susceptor for crystal growths of the tabular heated where a substrate is laid in the front face of an installation field, and, as for the periphery section of the aforementioned installation field, the technology which the heat capacity per the unit area is smaller than the center section of the installation field, and is carried out is adopted in the susceptor for crystal growths according to claim 1.
[0008] In this susceptor for crystal growths, since the heat capacity per the unit area was made smaller than the center section of the installation field, when the periphery section of an installation field is heated, also in the substrate in which the periphery section becomes low and temperature is laid for it compared with a center section, the periphery section becomes low temperature compared with a center section. Namely, if temperature becomes low, the thickness of the periphery section will be thinly corrected more thinly than before by low temperature relatively from a bird clapper, and as for the thickness of an epitaxial layer, the homogeneity of thickness [in / whole / a field] becomes high. Moreover, since the incorporation of the addition impurities (boron etc.) which the temperature of the periphery section falls and come out of an edge decreases while the resistance of an epitaxial layer will tend (boron becomes is hard to be incorporated) to become high, if temperature becomes low (when especially a dopant is boron), the resistance of the periphery section is corrected more highly than before by low temperature, and the homogeneity of resistance [in / whole / a field] becomes high.
[0009] In the susceptor for crystal growths according to claim 2, as for the periphery section of the aforementioned installation field, the technology which the thickness is thinner than the center section of the installation field, and is carried out is adopted in the susceptor for crystal growths according to claim 1.
[0010] In this susceptor for crystal growths, since the thickness is made thinner than the center section of the installation field, the periphery section of an installation field can make the heat capacity per unit area of the periphery section smaller than a center section easily and with high precision.
[0011] In the susceptor for crystal growths according to claim 3, as for the periphery section of the aforementioned installation field, the technology in which the slot is formed in either [at least] the front face or the rear face is adopted in the susceptor for crystal growths according to claim 1 or 2.
[0012] In this susceptor for crystal growths, since the slot is formed in either [at least] the front face or the rear face for the periphery section of an installation field, the thickness of the position of a slot becomes thin and can make the heat capacity per unit area as the whole periphery section smaller than a center section.
[0013] In the susceptor for crystal growths according to claim 4, as for the center section of the aforementioned installation field, the technology in which heights are formed in the rear face is adopted in the susceptor for crystal growths given in either of the claims 1-3.
[0014] In this susceptor for crystal growths, since heights are formed in the rear face of the center section of the installation field, the thickness of the position of heights becomes thick, the heat capacity per unit area of a center section can be made larger than the periphery section, and the temperature of the periphery section becomes low relatively.

[0015] In the susceptor for crystal growths according to claim 5, the technology set up according to the field interior division cloth of radiant heat with which the heat capacity per unit area of the aforementioned installation field is applied in case the front face of the aforementioned installation field is heated is adopted in the susceptor for crystal growths given in either of the claims 1-4.
[0016] In this susceptor for crystal growths, since the heat capacity per unit area of an installation field is set up according to the field interior division cloth of the radiant heat added in case the front face of an installation field is heated, even when a bias is in the distribution of the radiant heat added by lamp arrangement etc., the homogeneity within a field of thickness and resistance can be acquired with high precision by the heat-capacity distribution also in consideration of the intensity distribution. For example, when the distribution of the radiant heat added is changing by radial rather than is uniform, it becomes possible by changing the thickness of the periphery section to radial corresponding to this to set it as the heat capacity which was further suitable for the homogeneity within a field of the above-mentioned property.
[0017] With crystal-growth equipment according to claim 6, it is crystal-growth equipment which a substrate is laid [equipment] in a susceptor, it changes [equipment] into an elevated-temperature state, and reactant gas is passed [equipment] on a substrate, and grows up a crystal into a substrate front face, and the technology in which the aforementioned susceptor is a susceptor for crystal growths given in either of the claims 1-5 is adopted.
[0018] With this crystal-growth equipment, since a susceptor is a susceptor for crystal growths given in either of the claims 1-5, the epitaxial wafer excellent in the homogeneity within a field of thickness and resistance can be manufactured.
[0019] With an epitaxial wafer according to claim 7, it is the method of growing a crystal film epitaxially on a substrate front face, and manufacturing an epitaxial wafer, and it lays on the susceptor for crystal growths given [the aforementioned substrate] in either of the claims 1-5, and changes into an elevated-temperature state, and the technology of passing reactant gas and growing up the aforementioned crystal into the aforementioned substrate front face is adopted. Moreover, by the manufacture method of an epitaxial wafer according to claim 8, it is the epitaxial wafer with which the crystal film grew epitaxially on the substrate front face, and the technology in which the aforementioned crystal grew on the aforementioned substrate by the manufacture method of an epitaxial wafer according to claim 7 is adopted.
[0020] By this epitaxial wafer and its manufacture method, since lay a substrate on the above-mentioned susceptor for crystal growths, it changes into an elevated-temperature state, reactant gas is passed and the crystal is grown up into the substrate front face, it excels in the homogeneity within a field of the thickness of a crystal film, and resistance.
[0021]
[Embodiments of the Invention] Hereafter, the 1st operation gestalt of the crystal-growth equipment using the susceptor for crystal growths and this concerning this invention and an epitaxial wafer, and its manufacture method is explained, referring to drawing 1 and drawing 4 . In the sign 11, shown in these drawings, a chamber and 12 show the susceptor and 13 shows the susceptor axis-of-rotation member.
[0022] Drawing 1 and drawing 2 are what shows the single-wafer-processing epitaxial crystal-growth equipment of this operation gestalt. this epitaxial crystal-growth equipment The chamber 11 made from a quartz which is a circular airtight container in the air, and the susceptor 12 installed in a chamber 11, the susceptor axis of rotation made from a quartz supported possible [rotation of this susceptor 12] -- with the upper part of a chamber 11, and the halogen lamp which are arranged caudad and heats a susceptor 12 and silicon-substrate W, although it consists of a member 13, in addition not being illustrated [two or more] It has the upper part and the pyrometer which is arranged caudad and measures the temperature of a susceptor 12, or thermocouple of a chamber 11.
[0023] moreover, this epitaxial crystal-growth equipment is equipped with the gas induction 16 of reactant gas and the gas eccrisis section 17 which countered the lateral part of a chamber 11 mutually and were prepared, and the wafer carry in/out part which is prepared in the lateral part of a chamber 11 and carries out carrying-in appearance of the silicon-substrate W from the exterior on the susceptor 12 in a chamber 11 although not illustrated The aforementioned susceptor rotation shank material 13 is connected to the rotation drive which is not illustrated.

[0024] The aforementioned susceptor 12 is formed with the carbon by which the front face was covered in the silicon car band, and as shown in drawing 3 and drawing 4 , it consists of disc-like installation field 12a by which silicon-substrate W is laid in a front face, and boundary-region 12b formed in the periphery of installation field 12a in a circle at one. Between the front face of the aforementioned installation field 12a, and the front face of boundary-region 12b, when the level difference about [of silicon-substrate W] thickness is prepared and silicon-substrate W is laid in the front face of installation field 12a, it is set up so that the front face of boundary-region 12b and the front face of silicon-substrate W may be mostly located in a coplanar.
[0025] Cross-section rectangle-like in-a-circle slot 12c is formed [the periphery section] in the rear face of installation field 12a at a susceptor 12 and the same axle. That is, the thickness in in-a-circle slot 12c is thinner than the center section of installation field 12a, and the thickness in in-a-circle slot 12c is set as the abbreviation 1/2 of a center section with this operation form. 12d of fitting holes forms in the rear face of circumference field 12b at a circumferencial direction -- having -- **** -- 12d of each fitting hole -- the susceptor axis of rotation -- a member 13 is inserted and a susceptor 12 is supported
[0026] It connects with the source of supply (illustration abbreviation) of reactant gas, and the reactant gas used with this operation form consists of the trichlorosilan as source gas, a diboron hexahydride as P dopant gas, and hydrogen gas as carrier gas, and the aforementioned gas induction 16 is supplied in a chamber 11 from the gas induction 16. It connects with the processor (illustration abbreviation) of reactant gas etc., and the reactant gas used for this processor etc. within the chamber 11 is discharged, and the aforementioned gas discharge section 17 is processed. In addition, as silicon-substrate W which grows epitaxially, as shown in drawing 3 , the thing for MOS by which LTO (Low Temperature Oxide) which is a CVD oxide film was prepared in the rear face of the low resistance substrate (0.01 - 0.03 ohm-cm) W0 at which boron was doped by high concentration is used, and epitaxial layer (crystal film) E grows up to be a front face.
[0027] Next, the epitaxial crystal-growth method in the 1st operation form of the crystal-growth equipment using the susceptor for crystal growths and this concerning this invention and an epitaxial wafer, and its manufacture method is explained.
[0028] First, while carrying in silicon-substrate W which grows epitaxially in a chamber 11 from a wafer carry in/out part, it lays in the installation field 12a front face of a susceptor 12. Then, the temperature up of the temperature of silicon-substrate W is carried out even to predetermined temperature (1130 degrees C) with a halogen lamp, hydrogen BEKU is performed, and removal of a natural oxidation film and removal of surface discontinuity are performed. In addition, silicon-substrate W will be in an elevated-temperature state with the heat from the susceptor 12 mainly heated by the infrared radiation of a halogen lamp.
[0029] And it grows epitaxially on the front face of silicon-substrate W succeedingly by supplying reactant gas in a chamber 11 from the gas induction 16. It is discharged by the gas eccrisis section 17 shell exterior, after a crystal growth is presented on a silicon-substrate W front face, while flowing to ** on the other hand to the gas eccrisis section 17 which reactant gas counters from the gas induction 16 at this time. in addition, the time of growth -- a susceptor 12 and silicon-substrate W -- a rotation drive -- the susceptor axis of rotation -- it is rotated through a member 13 While stopping supply of reactant gas after growing epitaxial layer E epitaxially by the given thickness on a front face as shown in drawing 3 , the temperature is lowered, and silicon-substrate W W to which epitaxial growth was performed from the wafer carry in/out part, i.e., an epitaxial wafer, is taken out from the inside of a chamber 11.
[0030] With this operation gestalt, since the in-a-circle slot 12 is formed in the installation field 12 a round marginal part of a susceptor 12, the heat capacity per unit area of the periphery section is made smaller than the center section of installation field 12a. For this reason, when heated, also in silicon-substrate W in which the periphery section becomes low and temperature is laid for it compared with a center section, the periphery section becomes low temperature compared with a center section.
[0031] Namely, if temperature becomes low, the thickness of the periphery section will be thinly corrected more thinly than before by low temperature relatively from a bird clapper, and as for the thickness of epitaxial layer E which grows, the homogeneity of thickness [in / whole / a field] becomes high. Moreover, since the incorporation of the boron which the temperature of the

periphery section falls and comes out of the edge of silicon-substrate W decreases while will become [boron] is hard to be incorporated and the resistance of epitaxial layer E will tend to become high, if temperature becomes low, the resistance of the periphery section is corrected more highly than before by low temperature, and the homogeneity of resistance [in / whole / a field] becomes high. In addition, with this operation gestalt, the epitaxial wafer W which controlled the resistivity rho of epitaxial layer E to 9 - 11 ohm-cm is manufactured.
[0032] Next, the 2nd operation gestalt of the crystal-growth equipment using the susceptor for crystal growths and this concerning this invention and an epitaxial wafer, and its manufacture method is explained, referring to drawing 5 .
[0033] Although cross-section rectangle-like in-a-circle slot 12c is formed in the installation field 12 a round marginal part of a susceptor 12 with the 1st operation gestalt, a different point of the 2nd operation gestalt and the 1st operation gestalt is a point that in-a-circle slot 21b to which a channel depth becomes gradually deep at the method of the outside of radial is formed in the installation field 21 a round marginal part of a susceptor 21, with the 2nd operation gestalt, as shown in (a) of drawing 5 .
[0034] That is, when a bias is in the distribution of the radiant heat added to the front face of installation field 21a by lamp arrangement etc., in order to set it as the heat capacity corresponding to the intensity distribution, by forming in-a-circle slot 21b, the thickness of the periphery section of installation field 21a is gradually changed to the method of the outside of radial in the shape of a taper thinly, and the heat capacity per unit area in radial is controlled by this operation form. By this, even if a bias is in the distribution of radiant heat, the homogeneity within a field of thickness and resistance can be raised.
[0035] Moreover, according to the field interior division cloth of the radiant heat added in case the installation field 31a front face of a susceptor 31 is heated as other examples of this operation gestalt, as shown in (b) of drawing 5 , you may form so that in-a-circle slot 31b of an installation field 31 a round marginal part may become shallow gradually at the method of the outside of radial. In addition, in the example shown in (a) of drawing 5 , since it has set up so that heat capacity may become small gradually by in-a-circle slot 21b at the method of the outside of radial, it can prevent that a rapid temperature gradient does not arise in radial, but a slip is generated in silicon-substrate W.
[0036] Next, the 3rd operation form of the crystal-growth equipment using the susceptor for crystal growths and this concerning this invention and an epitaxial wafer, and its manufacture method is explained, referring to drawing 6 .
[0037] Although in-a-circle slot 12c is formed in the installation field 12 a round edge of a susceptor 12 with the 1st operation form, a different point of the 3rd operation form and the 1st operation form is a point that heights 41b projected to the rear-face side is formed in the installation field 41a center section of the susceptor 41, with the 3rd operation form, as shown in drawing 6 .
[0038] Moreover, with the 3rd operation form, it differs from the 1st operation form in that fitting hole 41c which inserts support pin (bearing bar) 13c in the center of heights 41b, i.e., the center of rotation, (center position of installation field 41a) is formed. in addition -- 41d of circumference fields -- the 1st operation form -- the same -- the rear face -- the susceptor axis of rotation -- fitting hole 41e which inserts a member 13 is formed Therefore, as for the susceptor rotation shank material 13, one support pin 13c is set up by the center.
[0039] With this operation gestalt, since heights 41b is formed in the rear face of the center section of installation field 41a, the thickness of the position of heights 41b becomes thick, the heat capacity per unit area of a center section can be made larger than the periphery section, and the temperature of the periphery section becomes low relatively. Moreover, even if it rotates a susceptor where support pin 13c is inserted in fitting hole 41c at the time of growth since fitting hole 41c is formed in heights 41b, since the center of rotation is supported by support pin 13c, eccentricity is prevented and the ununiformity of the thickness by eccentricity and resistance can be prevented. Furthermore, the fall of the heat capacity in fitting hole 41c can be compensated as the whole heights 41b, and the temperature fall of a center section can be suppressed.
[0040] In addition, this invention also includes the following operation forms. With each above-mentioned operation form, although the in-a-circle slot was formed in the rear face of an installation

field, you may form in a front face. In this case, change of the temperature distribution by reduction of a touch area with the silicon substrate laid etc. is also taken into consideration, and an in-a-circle slot is formed. Moreover, although the susceptor was mainly heated by infrared radiation with the halogen lamp as a heating method, you may adopt other heating methods and sources of heating. For example, you may mainly heat a susceptor with the high-frequency heating by the RF induction coil.
[0041] Furthermore, with each above-mentioned operation form, although applied to the epitaxial equipment of single wafer processing, it is not limited to this and you may apply to other methods (various batch types etc.). Moreover, although one in-a-circle slot was formed in order to make thickness of the periphery section of an installation field thin, you may form the slot of the configuration except in a circle. for example, the line which extended in the slot which consists of two or more dot-like holes, or radial at the radial -- you may form a slot etc. Moreover, the slot which consists of two or more in-a-circle slots is sufficient.
[0042]
[Effect of the Invention] According to this invention, the following effects are done so. According to the susceptor for crystal growths according to claim 1, since the heat capacity per the unit area is smaller than the center section of the installation field and the periphery section of an installation field is carried out, compared with a center section, temperature becomes [an installation field and the periphery section of a substrate] low, and it becomes possible to make the whole field equalize the thickness of an epitaxial layer compared with the case where temperature distribution are uniform. Moreover, since the incorporation of the addition impurity which the temperature of the periphery section falls and comes out of an edge decreases, low resistance-ization of the periphery section is prevented and homogeneity of resistance [in / whole / a field] can be made high.
[0043] According to the susceptor for crystal growths according to claim 2, since the thickness is made thinner than the center section of the installation field, the periphery section of an installation field can make the heat capacity per unit area of the periphery section smaller than a center section easily and with high precision by thick adjustment, and can raise the homogeneity of thickness and resistance further by suitable heat-capacity distribution.
[0044] According to the susceptor for crystal growths according to claim 3, since the slot is formed in either [at least] the front face or the rear face for the periphery section of an installation field, the thickness of the position of a slot can become thin, the heat capacity per unit area as the whole periphery section can be made smaller than a center section, and a suitable heat-capacity distribution can be obtained with simple composition.
[0045] According to the susceptor for crystal growths according to claim 4, since heights are formed in the rear face of the center section of the installation field, the heat capacity per unit area of a center section with heights becomes larger than the periphery section, the temperature of the periphery section becomes low relatively, and it becomes possible to attain thickness within a field, and equalization of resistance.
[0046] Since the heat capacity per aforementioned unit area is set up according to the field interior division cloth of the radiant heat added in case the front face of an installation field is heated according to the susceptor for crystal growths according to claim 5 and it is set as the heat capacity corresponding to the intensity distribution even if a bias is in the distribution of the radiant heat added by lamp arrangement etc., the homogeneity within a field of thickness and resistance can be raised further.
[0047] According to crystal-growth equipment according to claim 6, since a susceptor is a susceptor for crystal growths given in either of the claims 1-5, the epitaxial wafer excellent in the homogeneity within a field of thickness and resistance can be manufactured stably easily at the high yield, and it becomes possible to supply a quality epitaxial wafer by the low cost.
[0048] Since according to the manufacture method of an epitaxial wafer according to claim 7 and an epitaxial wafer according to claim 8 lay a substrate on the above-mentioned susceptor for crystal growths, it changes into an elevated-temperature state, reactant gas is passed and the crystal is grown up into the substrate front face, it can excel in the homogeneity within a field of the thickness of a crystal film, and resistance, and the yield can be raised also in subsequent semiconductor manufacture processes.

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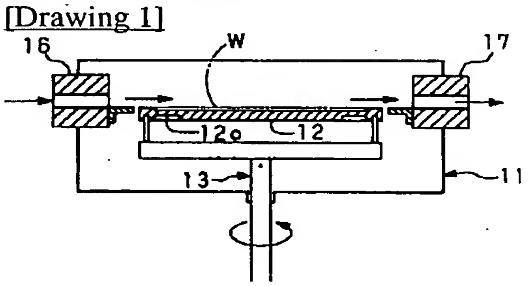
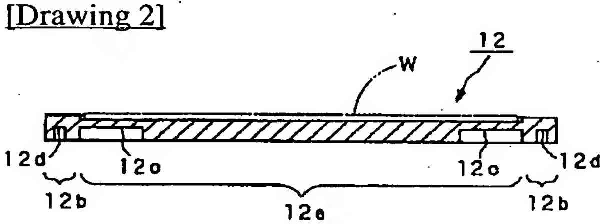
DRAWINGS

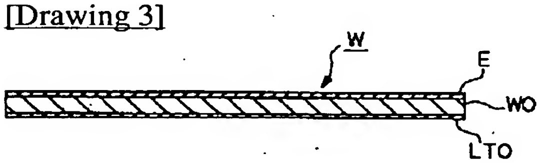
[Drawing 1]



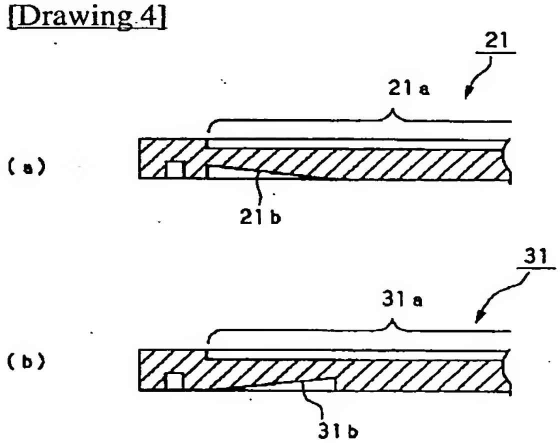
[Drawing 2]



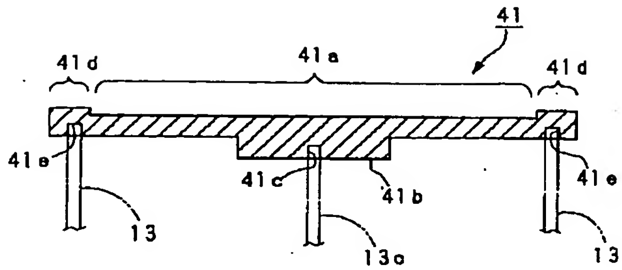
[Drawing 3]



[Drawing 4]



[Drawing 5]



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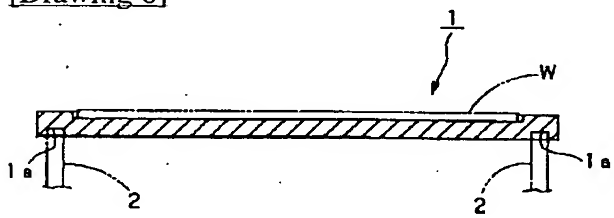
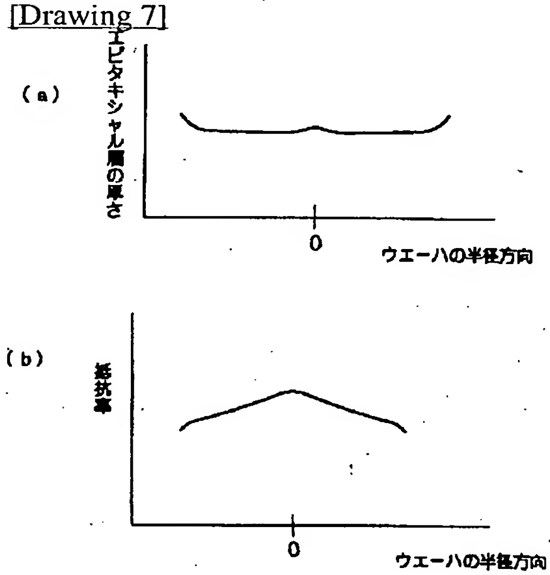


[Drawing 7]



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